Jerry Uttrachi, President

Low Pressure Gas Saver Devices Vs Gas Saver System

Shielding Gas Saving Article About A Low Pressure Alleged "Gas Saver" Published in a Prominent Journal is Foolish!

During my career *(with Linde, then as VP at L-TEC and ESAB the successors of Linde's welding businesses)* avoided putting a competitive product brand name in brochures etc. No need to give credibility, especially to a poor performing product. Although several products claim to reduce shielding gas waste, some can actually *"increase not decrease" total gas use* and are often rejected by welders! One of the worst offenders was promoted in an article in a prominent Journal; prompting this Report. A number of welding engineers discussed the poor performance of the product and removed it, one reported discarding 70. This Report shows why the use of this MIG shielding gas alleged *"savings devise"* discussed in the Journal article is foolish. The graph below shown in article (*also on their website*) displayed one of the low-pressure Harris Model 301-RF bad features, "*lack of starting purge gas," c*ausing inferior starts.

Frankly, I'd be embarrassed to show this published graph to anyone who understands what's required for quality MIG gas flow control. Unfortunately, it's not everyone MIG welding, managing MIG welding or managing fabrication who do!

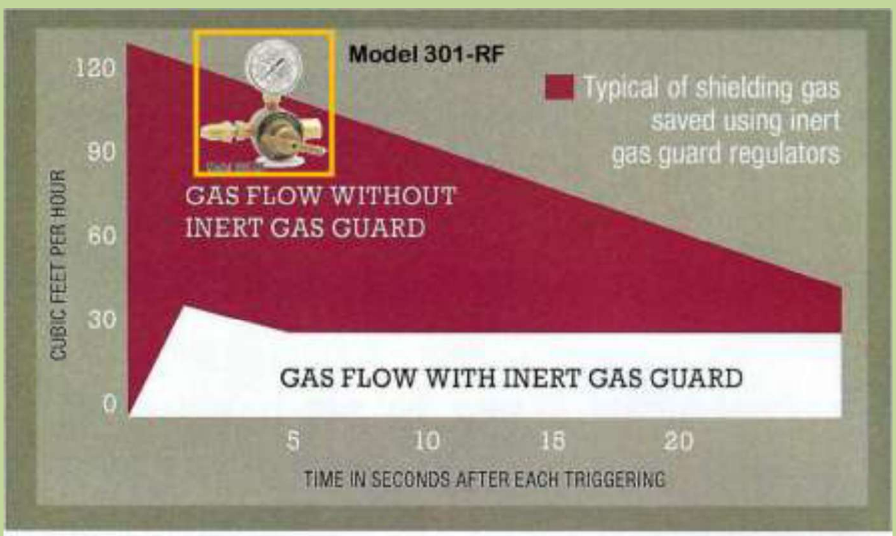


Fig. 1 — Inert gas guard regulators reduce gas surge when a gas metal arc gun or gas tungsten arc torch is activated.

This graph from the published article (left) shows it has insufficient extra gas to quickly purge air at the weld start. Note, I superimposed a picture of the Model it is based on, their 301 RF.

BUT its worst feature, is it eliminates Automatic Flow Compensation. The engineers who designed the early MIG and TIG flow controls in the 1950s understood and incorporated "choked flow" in their designs. That's why ALL ESAB/Victor, ITW/MILLER/Smith and other quality shielding gas flow control devices use a minimum of 25 psi- NOT foolish low pressure! Heck, even the cheap regulator flow controls from China use ~50 psi! In my discussions with Chinese engineers at the huge Beijing Welding Exhibition, all clearly understood the need for *"automatic flow compensation."* The following provides details of shielding gas flow control and shows why.

HISTORY

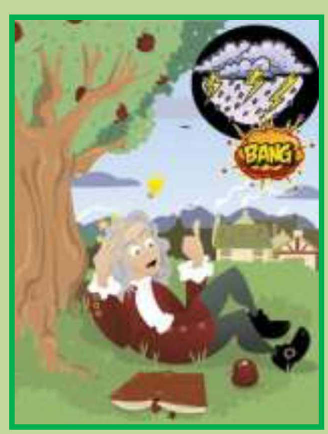
Shielding gas delivery systems were designed to work at higher pressure from the time the MIG and TIG processes were introduced in the 1950's for a very good reason. This extra pressure provides automatic flow compensation. We'll explain that phenomena in this Report. However, using higher pressure also causes a "gas blast" at each weld start that can waste about half the gas used by a typical MIG welder! Recently some have tried low pressure to solve this "gas blast" and waste issue. Unfortunately, this causes worse, less obvious problems and frequently unhappy welders!

My first exposure to a low-pressure device was ~1992 when touring the owner of a small gas apparatus manufacturer through our ESAB equipment manufacturing facility. He offered to sell us a low-pressure device (pic left) his engineers designed to reduce shielding gas waste. I was well aware of gas waste in MIG welding from working at Linde (*renamed Praxair*) where we had 60+% of the North American Argon production capacity. When Linde elected to divest of the welding equipment & filler metals business (*to focus resources on the very profitable Industrial Gas business*) the welding businesses were incorporated in a new business, L-TEC. I became a VP of L-TEC. We subsequently sold that company to ESAB where I remained as VP for 10 years before leaving to start WA Technology.

I knew all our flow control systems used a minimum of 25 psi and most sold at the time were 50 psi (*the typical shielding gas pipeline pressure*.) I asked one of our gas apparatus engineers, about this low-pressure design concept. He said, *"Won't work, that is why we use higher pressure above the flow control!"* He described the details of "choked flow" and "automatic flow compensation." Of interest, all Oxygen regulators for the medical field use 50 psi so restrictions in the supply hose and mask do not alter flow settings! When forming WA Technology in 1999 I visited a retired engineer and colleague who had been the Gas Apparatus Laboratory Division Head when I started working in the Linde R&D Welding & Cutting Lab. He worked in that department when MIG welding was introduced; well before I started in the industry. He described the reason a minimum of 25 psi was used above the flow control needle valve or orifice to achieve, "Automatic Flow Compensation." I was surprised at ~85 years old he quickly recalled the 2.1 ratio needed between the pressure upstream and downstream of the orifice or needle valve to achieve "choked flow." That explanation follows:

AUTOMATIC COMPENSATION MANAGES FLOW RESTRICTIONS

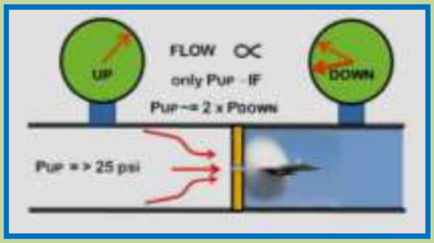
Shielding gas flow rate *will not change* with flow restriction changes *IF* the pressure upstream of the flow controlling device beit needle valve or orifice is more than 2.1 times the downstream pressure.



I find it interesting that Sir Isaac Newton in 1700rds (*the dude with the falling apple!)* would understand "choked flow" since he measured the speed of sound and investigated the speed of light. He helped define *"Why you see Lightening before you hear Thunder!"* The key is the pressure wave that causes sound to reach your ear can only travel at the speed of sound (770 mph.)

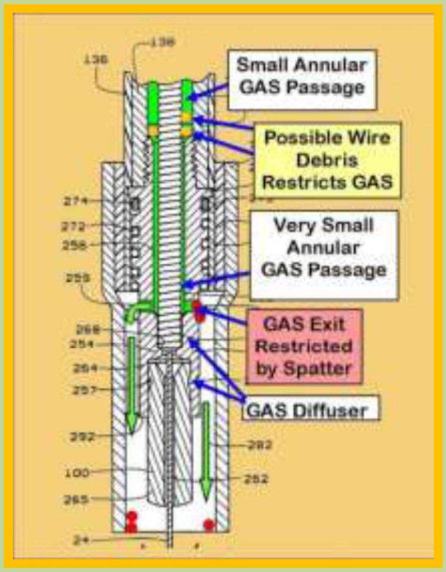
If Newton could understand the phenomena, so can you- we'll explain!

"Choked Flow" provides a flow control system that compensates for the shielding gas flow restrictions. Restrictions occur mainly in the MIG gun and cable as welding progresses. It does that with NO MOVING parts. If the pressure upstream of the flow control needle valve or orifice in a cylinder regulator/flowgauge is above 2.1 times the downstream pressure than the flow is determined NOT by the pressure differential BUT only the upstream pressure. Then flow restrictions can vary and flow remains fixed.



$$w = CA_2p_1\sqrt{\frac{2g}{RT_1}\frac{k}{k-1}\left(\frac{p_2}{p_1}\right)^{\frac{2}{k}}\left[\left(\frac{p_1}{p_2}\right)^{\frac{k-1}{k}}-1\right]}\Big/\sqrt{1-\left(\frac{A_2}{A_1}\right)^2\left(\frac{p_2}{p_1}\right)^{\frac{2}{k}}}$$

(*Note: Pressures are measured as absolute pressure, i.e. gauge reading + 14.7 psi, psia*. This phenomenon is caused by gas flow not being able to exceed the speed of sound in the small orifice or needle valve passage. ***The same reason you see lighting before you hear thunder!*** *The Math is complex but not exceeding the speed of sound, logical.)*



Automatic flow compensation is very important since as the welder moves, the shielding gas delivery hose may become twisted, contain bends creating a pressure drop. Also the gas passage in the MIG gun and cable usually doubles as the hose holding the wire spiral liner. It can partially clog with debris or copper flakes from the wire coating. Spatter builds in the MIG gun gas diffuser and nozzle; increasing pressure drop. However, as long as the restrictions do not exceed half (0.48 to be exact) the absolute pressure above the flow control, ***no flow change will occur***. The restrictions need not be noticed by the welder. They are **compensated for automatically** since the regulator or pipeline pressure is sufficiently high. With those pressures the gas velocity in the orifice or small gas passage in the needle valve will reach the speed of sound and cannot flow faster!

What Minimum Pressure is Needed to Achieve Automatic Flow Compensation?

The bottom line is 25 psi (40 psia) is needed; here's why. The pressure needed to flow gas at normal welding rates in a MIG system though the solenoid, wire feeder gas fittings, gun gas line, gas diffuser and out the torch nozzle can vary from as low as 3 psi to as high as 8 psi. For the typical 5 psi average, to assure automatic compensation for restrictions that occur in production, the pressure upstream of the flow control device should be twice 5 psi stated in absolute pressure (*usually labeled psia.*) Or the absolute pressure needed at the feeder, = 5 psi + 14.7 psi atmospheric pressure = **19.7 psia**. The pressure upstream of the flow control device must be 2 X 19.7 psia = **39.4 psia**. To put it back to gauge pressure, which is usually displayed, 39.4 psia - 14.7 psi = **24.7 psi. Therefore 25 psi (*as measured on a gauge*) is the minimum pressure that should be available.** It is no coincidence that this pressure (*or higher*) is designed into quality shielding gas flow control flowmeters, regulator/flowmeters or regulator/flowgauge systems! Also, gas pipeline pressures are usually about 50 psi, well above the minimum 25 psi needed. It was designed that way for MIG and TIG about the time these processes were invented by engineers who understood the inevitable flow restrictions found in use!

These companies also designed, developed, and marketed MIG welding systems. They were NOT just in the business of making gas apparatus. Those who introduced low pressure systems perhaps did not understand the MIG flow restriction issues!

If the pressures used are lower than this minimum 25 psi, any changes in restriction will result in changes in flow rate. If this occurs on a device having a flow calibrated pressure gauge to display flow rate (as the Harris 301-RF,) the welder will not even know the flow changed. Since the flow calibrated pressure gauge is reading upstream pressure it would still read the same and not the changed flow rate!

That is why all shielding gas *"quality flow control systems"* have used minimum pressures above 25 psi since the 1950's when MIG (and TIG) were introduced. A few gas apparatus manufacturers who were NOT in the MIG and TIG system design business apparently did not appreciate the need and attempted to utilize low pressure to "solve the gas waste problem." Most have not lasted long in the market since users and welders find the problems they cause.

LOW PRESSURE DEVICES

TEST: The following table provides test results with a **conventional** flow control device (left) that operates at 25 psi and a commercial **low-pressure** Harris Gas Guard 301-RF system (right) subjected to varying restrictions. Both were initially set to flow 31 CFH as noted in **Blue**. The controls were left at the initial settings as if they were padlocked. MIG gun restrictions were then added and removed (*as if the gas ports were alternately clogged and cleaned*) to vary the amount of restriction. Resulting flow rates, measured at the MIG Gun nozzle exit using a portable flowmeter, are shown in the table below.

Flow Control System Pressure	< Typical Production Restriction Range in psi >					
	3 psi	4 psi	5 psi	6 psi	7 psi	8 psi
Conventional = 25 psi	31 CFH	31 CFH	31 CFH	31 CFH	31 CFH	31 CFH
Harris 301-RF Low Pressure= 9 psi	37 CFH	34 CFH	31 CFH	27 CFH	23 CFH	16 CFH

The **Conventional System** was a standard regulator/flowmeter with an outlet pressure of 25 psi upstream of the flow control needle valve. Note the shielding gas flow remained at the preset, desired level of 31 CFH even when the restrictions in the feeder/gun system ranged as low as 3 psi to as high as 8 psi, the typical range found in production.

The Harris Gas Guard low pressure regulator device tested installs at the wire feeder and is sold to reduce the shielding gas surge at the start. Note the gas flow (*which, as mentioned above was set at 31 CFH at the nominal 5 psi restriction in the system and then locked in place*) varied from 16 CFH to 37 CFH as restrictions were added and removed from the system. The **flow control settings and regulator pressure** did not change; it remained at 9 psi in this case. **Unfortunately the flow calibrated pressure gauge included with the Harris model 301 is only reading the 9-psi pressure so it did not change either! It read about 31 CFH for all the tests!**

This gives the false impression that the flows remained constant. You can be out of the flow range defined in your Welding Procedure Qualification and not know it! Only a measurement at the gun nozzle reveals the gross error.

Although this Harris 301-RF **low-pressure device** tested showed poor performance ***any low-pressure device has similar problems!*** In fact, the add-on one pictured right created more flow variations in our tests. There are also models sold that mount at the gas supply that have similar problems.

Harris introduced a cylinder regulator/flowmeter Model 351 (photo left) and mentioned in literature, ***"operates at pressures lower than normal."*** BUT they didn't say the consequence, which they could have - "***this lower pressure causes wide flow variations when welding!"***

SUMMARY: Low pressure devices, ***do not*** have the ability to compensate for typical production MIG gun/TIG torch flow restrictions. In addition, for many MIG guns, the gas passage in the gun cable doubles as the passage holding the wire spiral liner. This passage can clog with debris such as drawing lubricate, copper flakes etc. The above test results show very significant flow changes can occur with low pressure systems. If a flow calibrated pressure gauge is used to measure the flow the change it will not be seen! With adequate pressure (*above 25 psi*) the flow will not change; it will be automatically compensated. What is a bit scary, is in discussions with Chinese Engineers at the very large Beijing Welding Exposition, they were all aware of the need for "Automatic Flow Compensation" and all their devices use ~3 bar = ~50 psi!

Another Major Problem of Low-Pressure Devices That Control Flow At The Wire Feeder or Welder

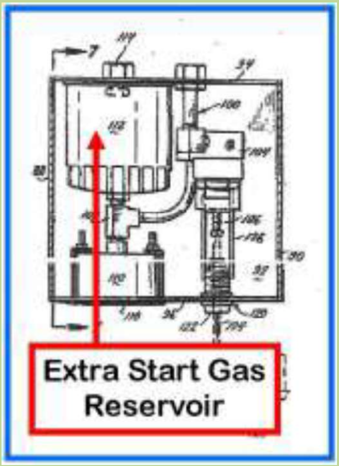
Low Pressure Devices Mounted at the Welder or Wire Feeder Also Have Poorer Start Performance Than Our Simple, Low Cost, Patented Gas Saver System (*GSS*)

This chart by Harris was in the prominent Welding Journal article for their Model 301 (*the one we tested.*) It mounts at the wire feeder or welder gas inlet. It illustrates a problem created by controlling flow at the wire feeder- insufficient starting gas purge of air.

I added the Orange curve on the graph of what our ***GSS*** achieves. The Harris low pressure device, as noted, delivers essentially no extra start gas. It also shows it takes about 2 seconds to reach the desired flow; far too long to provide enough gas to quickly purge the weld start area of moisture laden air. Our ***GSS*** (*orange dotted line we added to the graph*) quickly supplies the needed amount of purge gas at a limited peak flow rate, avoiding excess turbulence. The ***GSS*** still saves about 85% of the starting gas waste from a normal gas delivery hose, typically saving from 40 to 50% of the total gas used as reported by fabricators.

The Need for Extra Start Gas Clearly Defined

Stauffer in a 1982 patent of a gas saver system clearly defined the need for some extra gas at the weld start. In states in his patent, "... ***air leaks back into the torch and lines when welding is stopped. The air must be quickly purged and replaced with inert gas to produce high quality welds. Also, it is critical to displace the air at the weld zone of the work piece upon initiating the weld.*** "



The Stauffer Device used lower than 25 psi (*but higher pressure than the Harris* Gas *Guard 301-RF*) and used a large gas reservoir to store purge gas as noted in the patent figure.

NOTE: Our patented ***GSS*** does NOT alter the system pressure and although the stored gas is 80% less than a normal ¼ inch ID gas delivery hose, it provides enough extra gas AND at a maximum flow rate that DOES NOT produce excess turbulence. That maximum peak gas flow at weld starts is controlled with a restriction orifice in the hose fitting on the welder/wire feeder end.

Fun Story About The Stauffer Patented Device Actually Wasting Gas

The Stauffer patented device was initially marketed by Valmont. It used a ~10 cubic inch gas storage reservoir (yellow circle Pic right) to store the needed gas purge at the weld start. That size was needed because its biggest flaw was it used lower pressure BUT not as low as the Harris 301-RF Gas Guard. The case was all welded so to access the internals, tack welds had to be ground off (*which we did on one found to test!*) When we were L-TEC we sold >100 unique fast rise pulse MIG welders to John Deere Ankeny Iowa that cut welding fumes in half. The fast rise requirement was discovered by John Deere R&D. However, in combination of the typically high "gas blast" at weld starts that pulled in air, starts were harsh. I recall a phone call from the sales manager of our L-TEC distributor who sold the pulse MIG welders. He said he significantly improved the starting with Valmont's! When I was working in Linde's Corporate office, this sales manager had been on our distributor advisory council, which I Chaired. I jokingly said, *"Boy that will cost you gas business!"* He laughed and asked, if I ever cut one open and looked inside? He said it has many fittings, hose connections and leaks far more shielding gas than it saves! ***BUT the extra purge gas supplied at a limited velocity helps weld starts!***

An Example of Gas Waste with Harris 301-RF* Gas *Guards

A clear example of gas waste with the Harris 301-RF Gas Guards was found on one of the local bar joist fabricators where we installed 50 ***GSS***. Saved over 30% gas waste and most important to the welding engineer, it made happy welders (*who had wanted higher flow)* with better weld starts. It reinforced in my mind that some extra starting purge gas is needed at a Laminar NOT Turbulent velocity. Welders may NOT understand the science BUT observe if flow is set at the wire feeder by whatever device Regulator, Orifice or Flowmeter, there is not sufficient start gas to purge air. As in this case, they may set a high steady stated flow in attempt to compensate. Only a partial help. Welders may NOT know why but know the starts improve. ***In this shop, the Harris 301 RF was actually, wasting NOT saving gas!*** (*Application specifics are in the next section.)*

Fabricators Reporting Problems with Low Pressure Devices and Orifices Placed at The Wire Feeder to Set Flow

A number of fabricators have found these Harris Gas Guard devices create problems and had them removed and discarded. The following four fabricators reported their experiences:

Automotive OEM Supplier

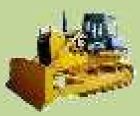
A welding engineer in a plant who purchased 32 of the Harris 301-RF low pressure Gas Guard flow control devices, same one we tested stated:

"After purchasing and using 32 low pressure "so called" gas saving devices that mounted at the wire feeders we decided to discard all of them! There were two major problems:

1) *Lack of sufficient extra gas at the start made inferior welds and*

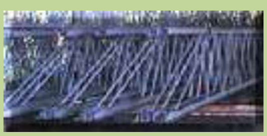
2) *Large flow variations from preset levels were evident when flow was checked at the MIG gun. He also stated; "Even if the flow was blocked, the flow calibrated pressure gauge supplied with these devices had the same preset reading!"*

Heavy Equipment Manufacturer



A very interesting example of problems with the same low-pressure Harris 301-RF was discovered after extensive testing. This fabricator had two plants making the exact same part. Both used the same MIG solid wire, gas, welding conditions etc. However, one was getting porosity and the other none. The welding engineer and friend, created a very detailed, 30 variable "Root Cause and Effect Fishbone Analysis" and gave me to review because he felt the porosity was caused by a shielding gas issue. Turned out it was! The key problem was the plant having porosity was using low-pressure regulator, Harris Gas Guard 301's mounted at the wire feeders! They were removed and the issue was resolved. It's possible the variable flow rates being encountered caused welders to set excessive steady state flow rates pulling moisture laden air into the shielding gas stream. The flow-calibrated pressure gauge on the Harris 301-RF would not show these flow rate variations. *Even if flow is blocked, the 301-RF flow calibrated pressure gauge would still read the initial flow setting!"*

Bar Joist Manufacturer Discards 50 Low Pressure "Gas Guards"



A Bar Joist manufacturer with 50 MIG welders purchased low-pressure Harris Gas Guards. They found welders were continually setting excessive flow rates. All 50 were supposed to have been discarded and replaced with fixed orifices at the wire feeders. Welders still wanted "more flow" so we were asked to help.

Of interest, when touring the plant, we found one Model Harris 301-RF, which surprised the welding engineer since they were all to be removed and discarded. It was set at 80 CFH, about the highest possible setting! Appears the welder was trying to compensate for the lack of extra starting gas. Controlling flow with an orifice at the feeder (*which they were doing when I got involved*) also eliminated the needed starting shielding gas purge! After successful tests, the plant put 50 ***GSS***'s on all MIG welders (*putting the fixed orifices at the pipeline gas drop.)* Welders were pleased even with the now reduced 40 CFH steady state flow as the *GSS* provided the needed extra start gas with a peak flow of ~70 CFH for a short time. Gas savings were about 30% achieved using reduced pipeline pressure.

Catalytic Converter Production

A manufacturer of catalytic converters had 70 new robotic MIG welding cells installed. The systems integrator installed a model of low-pressure Harris Gas Guard flow control regulators at each pipeline drop. However, it was quickly observed by the welding engineer that flow variations were occurring when measured at the gun nozzle on the MIG welding robots. He called Harris who could not fix the problem and blamed his robot welders! After seeing information on our website, he called and said although they blamed my robot welders, I had two Miller semiautomatic welders with the same flow variations! I recommended he replace the Harris low pressure regulators with conventional flowmeters mounted at the pipeline, flows remained at preset levels during production. That solved all shielding gas flow problems! To save gas waste our ***GSS*** would be installed after those quality flow control devices!

Low Pressure Devices Are NOT The Only Problem:

The issue of insufficient start gas occurs with other devices tried to reduce the starting gas surge and gas waste. We have found welders often rightfully reject them because of inferior weld start! They may not why but see the inferior result.

ORIFICES PLACED DIRECTLY AT FEEDER/WELDER

Simple orifices can be placed at the welder or wire feeder to set the steady state flow rate. They eliminate the starting "gas blast" but cause another less obvious problem, lack of gas to purge air from the weld start area and gun nozzle!

Welders often complain when simple orifices, flowmeters or regulators are added at the wire feeder or welder to set flow! Management frequently believes the welders just don't care about saving gas. Frankly in the past I would often support their assessment! In the past 15+ years, visiting a number of fabricators and running gas saving tests I now understand why the welders complain! They may not know the technical reason, which is the lack of extra gas quickly supplied to purge air from the weld start area. If they increase the steady state flow the observed problem is reduced! Not a solution, but better starts although wasting gas!

REGULATORS PLACED DIRECTLY AT WIRE FEEDER

Some products reduce the "gas blast" but have the same lack of purge gas as a simple orifice. (Examples are the Victor SLR 100 below left and Airgas "Gas Guard" below right.) These are regulator flow controls. Unlike low pressure devises they use pressures above 25 psi so can maintain the flow setting.

However just like a simple orifice, these devices *DON'T* provide the needed extra gas to purge the weld start area and MIG nozzle. Some are also adjustable so welders may increase the flow trying to compensate for the lack of start gas. Most welders have no doubt done what I have from time to time, started to weld forgetting to turn on the gas cylinder! They can see the result of lack of purge gas, as Staufer Defined in his patents (see Page 6.) If they can, they just increase the steady state flow. Perhaps a better start but that cannot match a higher peak flow rate supplied quickly by having stored gas in the hose attached to the wire feeder and peak flow limited by an orifice to a less turbulent as our *GSS* supplies.

FLOWMETER PLACED AT WIRE FEEDER GAS INLET

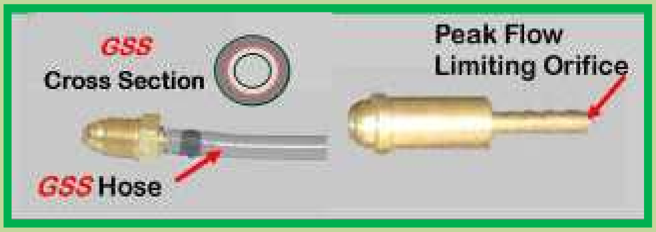
Another bar joist manufacturer with 100 welders had installed flowmeters at the gas inlet to reduce starting gas surge (picture left.) During a visit I was able to see what flows they were using. None were set under 50 CFH with about 50% set from 50 to 60 CFH.

About 25% were set near the top of the max reading on the flow tube, 70 CFH and 25% had the flow ball pinned to the top. On average they were using 70+ CFH! In my opinion welders were trying to compensate for the lack of starting gas purge by increasing the steady state flow. *They were wasting NOT saving shielding gas!* Increased steady state flow cannot fully accomplish what the *GSS* provides, which is a controlled amount of gas quickly supplied for about a second to second and a half. Increasing the steady state flow helps but not fully and wastes not reduces shielding gas use.

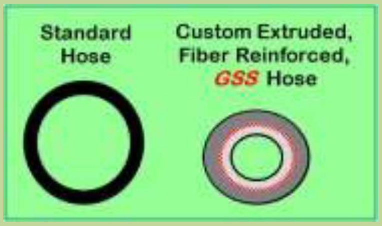
BOTTOM LINE

Low pressure devices reduce the "gas blast" at the weld start and, on the surface appear to reduce gas waste. However, they do ***NOT*** maintain "automatic flow compensation." When mounted at the wire feeder to control flow, like any device doing that, it causes a lack of needed extra starting gas to purge air from the weld start zone. ***The worst case*** is the Harris 301-RF low pressure device that mounts on the wire feeder causing variations in flow ***AND*** lack of needed extra start gas! Any device controlling flow at the wire feeder inlet causes the lack of sufficient purge gas!

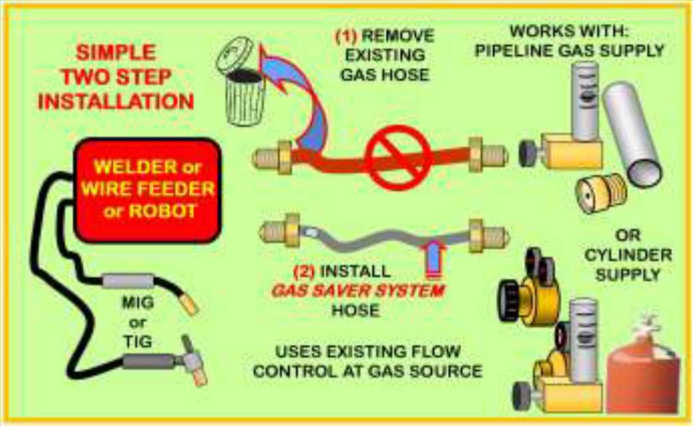
A simple, inexpensive, patented solution, our ***GSS*** solves the "gas blast" and gas waste using a totally different approach that ***MAINTAINS*** automatic flow compensation. The ***GSS*** ***DOESN'T*** alter system pressure! It reduces the volume of gas stored in the gas delivery hose each time welding stops by employing a custom extruded, small ID large OD hose. (*Note, we have customers using 100-foot long* ***GSSs***.) The ***GSS*** also quickly provides a controlled amount of extra gas at the weld start to purge the weld start area of air.



The ***GSS*** limits the maximum peak flow rate at weld start avoiding excess turbulence. It does that with no moving parts or extra connections that can leak, by employing a peak flow control orifice built into the end fitting hose barb! A combination of low hose volume and small pressure drops saves 80 to 85% of gas waste at each MIG gun torch trigger pull, even when just inching the wire to position before starting.



The low cost ***GSS*** is also easy to install. Simply replace the existing gas delivery hose from flow control at the gas supply to the welder/wire feeder/welding robot. No other changes are required. No knobs to adjust or parts to wear. Fabricators report average total gas savings of 40 to 50%. Those making short welds have reported over 60% gas savings. In addition, many report the savings from the improved weld start quality are even more important for their applications.



Perhaps ***Most Important***, welders see and appreciate the improved starts over a conventional gas hose and it's "gas blast" at weld starts. They often ***REJECT*** other attempts at saving gas that eliminate the "gas blast" but cause a lack of sufficient starting shielding gas purge of air in the weld start area.

They ***LOVE*** the ***GSS*** performance with its improved weld starts! Well ***OVER 15,000 GSS***'s are in use at industrial fabricators.